AS91390 Demonstrate understanding of thermochemical principles and the properties of particles and substances

COLLATED QUESTIONS

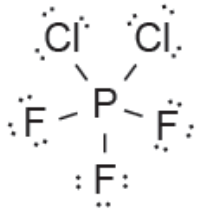
Lewis structures and shapes (up to six electron pairs about the central atom for molecules and polyatomic ions, including those with multiple bonds), polarity of molecules.

2023:1

(a) Complete the table below:

	SeF_4	SF_6
Lewis diagram		
Name of shape		

(b) The Lewis structure for phosphorus trifluorodichloride, PF_3Cl_2, is shown by:



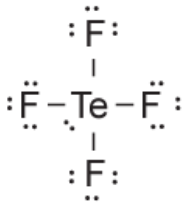
Identify and explain the shape and polarity of PF_3Cl_2.

2022:1

(a) Complete the table below:

	$BrCl_5$	BrF_3
Lewis diagram		
Name of shape		

(b) Tellurium tetrafluoride, TeF_4, has the following Lewis structure and shape:



seesaw

Identify and explain the polarity of TeF_4 .

Your answer should include an explanation of the shape.

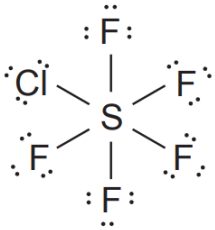
2021:1

(b) (i) Complete the table below:

	SeF_4	ClF^-
Lewis diagram		
Name of shape		

2021:3

(c) The Lewis structure for chloropentafluorosulfane, $SClF_5$, is given below:



Identify and explain the shape and polarity of $SClF_5$.

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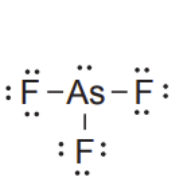
2020:3

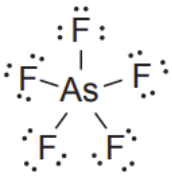
(b) (i) Complete the table below:

	BrF_3	PCl_6^-
Lewis diagram		
Name of shape		

(ii) The Lewis structures and shape names for AsF_3 and AsF_5 are shown below.



Trigonal pyramidal



Trigonal bipyramidal

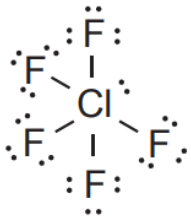
Compare and contrast the shapes and polarities of AsF_3 and AsF_5.

2019:1

(b) Complete the following table:

	SF_4	SF_3^-
Lewis diagram		
Name of shape		

(d) The Lewis structure of ClF_5 is given below.



Identify and explain the shape and polarity of ClF_5.

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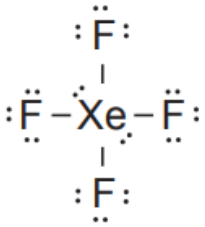
2018:1

(c) (i) Complete the following table:

	AsF_5	BrF_5
Lewis diagram		
Name of shape		

(ii) The Lewis diagram and shape for XeF_4 are given below.



square planar

Elaborate on the shape and polarity of XeF_4.

2017:3

(c) Iodine forms a linear I_3^- ion.

(i) Draw the Lewis structure for the I_3^- ion.

(ii) Explain why the I_3^- ion has a linear shape.

(iii) IF_5 has a square pyramidal shape.

Indicate whether the molecule IF_5 is polar or non-polar. Circle your choice.

polar non-polar

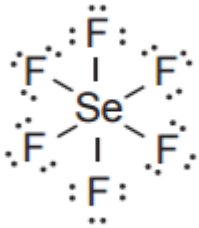
Justify your choice.

2016:1

(c) (i) Complete the following table:

	ICl_4^-	ClF_3
Lewis diagram		
Name of shape		

(ii) The Lewis diagram for SeF_6 is shown below.



Would you expect SeF6 to be soluble in water? Yes No

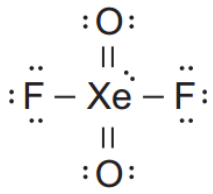
Explain your answer in terms of the shape and polarity of SeF_6.

2015: 3

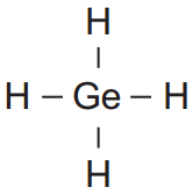
(a) Draw the Lewis diagram and name the shape of

- AsF_5
- SeF_6.

(b) The Lewis diagrams and shapes for XeO_2F_2 and GeH_4 are shown below.



see-saw



tetrahedral

Compare and contrast the polarities and shapes of these two molecules.

2014: 3

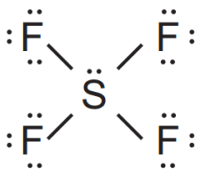
(a) In New Zealand, fluoride for water treatment is supplied as sodium fluorosilicate, Na_2SiF_6. One of the ions formed in the solution from sodium fluorosilicate is SiF_6^{2-}. Draw the Lewis diagram and name the shape of SiF_6^{2-}.

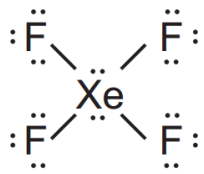
2013:1

(c) (i) Draw the Lewis diagram and name the shape of

- BF_3
- PCl_6^-

(ii) The Lewis diagrams for SF_4 and XeF_4 are shown below.





Compare and contrast the polarities and shapes of these two molecules.

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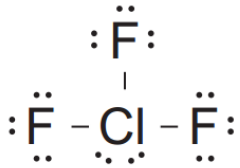
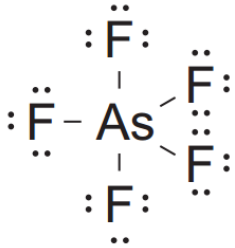
2012: 2 (From expired AS 90780)

(a) For the following molecules, draw the Lewis diagram, draw a diagram of the shape, and name the shape.

- SF_6
- SF_4

(b) The Lewis diagrams for ClF_3 and AsF_5 are shown below.





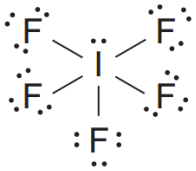
Compare and contrast the shape and polarity of these molecules.

2011: 2 (From expired AS 90780)

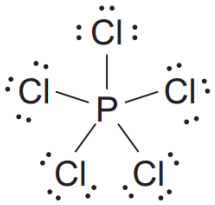
(a) Draw Lewis diagrams for IF_3 and NF_3, and name their shapes.

(b) The Lewis diagrams for IF_5 and PCl_5 are shown below.

IF_5



PCl_5



Discuss the polarities of these molecules.

2010: 2 (From expired AS 90780)

(a) For the following molecules, draw the Lewis diagram, draw a diagram of the shape, and name the shape.

- SF_4
- XeF_4

(b) Discuss the fact that although both SF_4 and XeF_4 have four bonds around the central atom, the molecules have different shapes and polarities.

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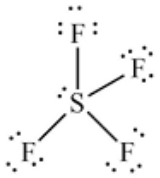
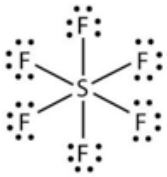
Answers

2023:1

(a)

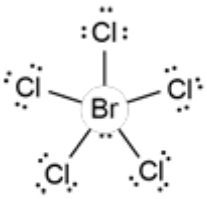
	SF_4	SF_6
Lewis Structure		
Shape	seesaw	octahedral

(b) PF_3Cl_2 has five areas of electron density around the central P atom, all of which are bond pairs. Repulsion between these five areas of electron density results in the trigonal bipyramidal shape to maximise separation and therefore minimise repulsion. F and Cl are each more electronegative than P, so the P–F and P–Cl bonds are polar covalent. Although the dipoles are symmetrically arranged, Fluorine has a different electronegativity to Chlorine so the P–F dipoles have a differing strength/are different from the P–Cl dipoles. As a result, the dipoles do not cancel out, and therefore PF_3Cl_2 is a polar molecule.

2022:1

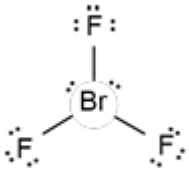
(a)

$BrCl_5$:



Square pyramidal

BrF_3:



T-shaped

(b) TeF_4 has five areas of electron density around the central atom. Repulsion between these five areas of electron density results in a trigonal bipyramid base shape to maximise separation / as far apart as possible. There are four bond pairs and one lone pair. So the molecular shape is seesaw. F is more electronegative than Te, so the Te–F bonds are polar covalent. Due to the lone pair on the central atom / seesaw shape the dipoles are asymmetrically arranged and therefore do not cancel, so TeF_4 is a polar molecule.

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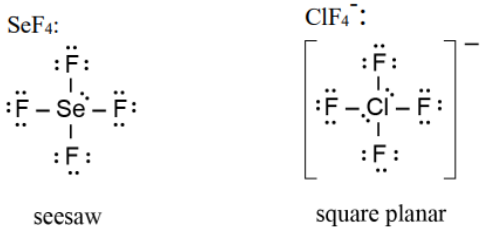
2021:1

(b) (i)

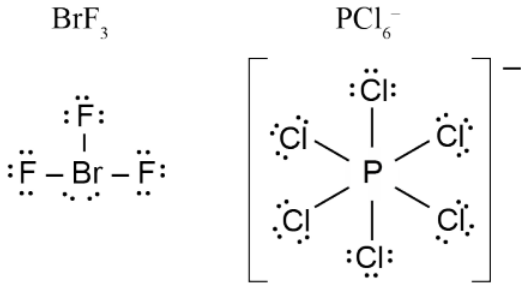


seesaw square planar

2021:3

(c) F and Cl are each more electronegative than S, so the S – F and S – Cl bonds are polar covalent. $SClF_5$ has six areas of electron density (six electron clouds) around the central S atom, all of which are bond pairs. Repulsion between these six areas of electron density results in the octahedral shape to maximise separation and therefore minimise repulsion. Although the dipoles are symmetrically arranged, the S – F dipoles have a differing strength from the S – Cl dipole. As a result, the dipoles do not cancel out, and therefore $SClF_5$ is a polar molecule. (Opposite S–F dipoles cancel, but the S–F and the opposite S–Cl dipoles do not cancel. Thus, the $SClF_5$ molecule has a dipole.)

2020:3



(c) (i) T-shaped octahedral

(ii) For both AsF_3 and AsF_5, F and As have different electronegativities, so the As – F bonds are polar covalent.
However, AsF_3 has four electron clouds / areas of electron density around the central atom, including three bond pairs and one lone pair / non-bonding pair. Repulsion between these four electron clouds results in the trigonal pyramidal shape to maximise separation. Due to the lone pair on the central atom, the dipoles are asymmetrically arranged and therefore do not cancel, so AsF_3 is a polar molecule.
In contrast, AsF_5 has five electron clouds / areas of electron density around the central atom, all of which are bond pairs. Repulsion between these five electron clouds results in the trigonal bipyramidal shape to maximise separation. The dipoles are symmetrically arranged and therefore cancel out to make AsF_5 a non-polar molecule.

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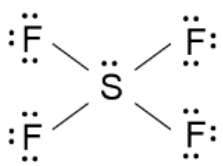
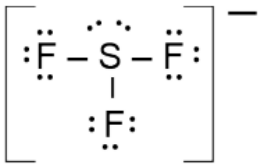
2019:1

(b)



see-saw

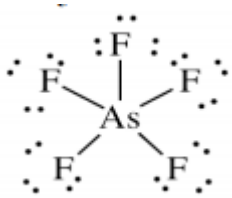
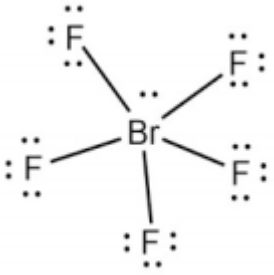


T-shaped

(d) ClF_5 has six electron clouds about the central atom, including five bond pairs and one lone pair. The electron clouds repel as far apart as possible; this produces the square pyramidal shape. There is an electronegativity difference between Cl and F, so the Cl–F bonds are polar covalent. The square pyramidal shape arranges these dipoles asymmetrically due to the lone pair on the central atom. The dipoles do not cancel so ClF_5 is a polar molecule.

2018:1

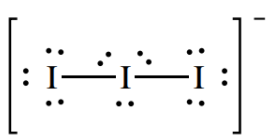
(c) (i) Complete the following table:

	AsF_5	BrF_5
Lewis diagram		
Name of shape	Trigonal bipyramidal	Square based pyramid

(ii) There are six electrons clouds about the central atom; four bond pairs and two lone pairs of electrons. The six electron pairs about the central Xe atom are arranged as far apart as possible in an octahedral geometry to minimise repulsion, but due to the two lone pairs, XeF_4 has a square planar shape. There is an electronegativity difference between Xe and F, so the Xe-F bonds are polar covalent. This molecule is symmetrical due to the position of the two lone pairs around Xe being above and below the plane, so the effect of the bond dipoles cancel, i.e. there is an even spread of charge. Therefore, XeF_4 is a non-polar molecule.

2017:3

(c) (i)

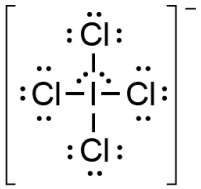


(ii) Arrangement of areas of electron density around the central I atom is trigonal bipyramidal due to five regions of negative charge. These areas all repel each other. As there are three non-bonding pairs (in the equatorial area) and two bonded atoms, the shape is linear.

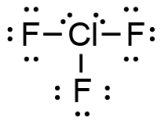
(iii) Polar. The I-F bond is polar due to a difference in electronegativity. There are six regions of negative charge giving IF_5 an octahedral geometry. The five bonded and one lone pair around the central iodine atom gives it the square pyramid shape. This means the molecule is asymmetric so the bond polarities dipoles don't cancel causing the molecule to be polar.

2016: 1

(c) (i)



ICl_4^-: Square planar

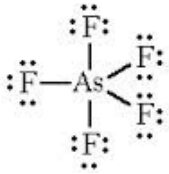


ClF_3: T-shaped

(ii) No. There is an electronegativity difference between Se and F, so the Se-F bonds are polar covalent. The six bond pairs around the central Se atom arrange themselves as far apart as possible to minimise repulsion, so SeF_6 has an octahedral shape. Since this is a symmetrical shape, the bond dipoles cancel out, so SeF_6 is a non-polar molecule. Water is a polar solvent. Non-polar molecules like SeF_6 are not attracted to polar molecules like water, i.e. the intermolecular attraction between the water molecules and the SeF_6 molecules is insufficient to overcome the attraction between the water molecules. Therefore, SeF_6 is insoluble in water.

2015: 3

(a)



Trigonal bipyramidal

Octahedral

(b) XeO_2F_2 is polar. It has 5 areas of electron density around the central Xe atom, one of which is a lone pair. Maximum separation for minimum repulsion means that the shape is based on a trigonal bipyramid structure, but is actually see-saw. The Xe=O bonds are polar, due to the greater electronegativity of O, and the Xe-F bonds even more polar, due to the F atom having the highest electronegativity on the periodic table. The molecule is not symmetrical, and so the dipole moments cannot cancel, making the molecule polar.

(c) GeH_4 is non-polar. It has 4 areas of electron density around the central Ge atom, all of which are bonded. Maximum separation for minimum repulsion means that the shape is tetrahedral. This is a symmetrical structure, thus the bond dipole moments cancel, and therefore the molecule is non-polar.

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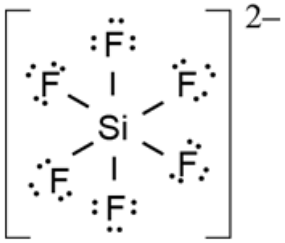
2014:3

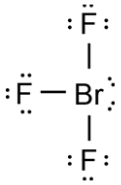
(a) 

Octahedral

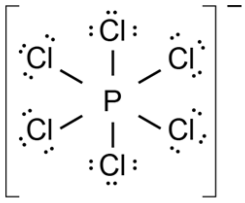
2013: 1

(c) (i)

BrF_3: T-shaped:



PCl_6^-: Octahedral



(ii) There is a difference in electronegativity between S and F, so the S-F bonds are polar covalent. SF_4 has a see-saw shape (distorted tetrahedron) due to the repulsions between four bonding regions and one non-bonding region of charge, which is asymmetric therefore the polarities/dipoles do not cancel. As a result, SF_4 is a polar molecule.
There is a difference in electronegativity between Xe and F, so the Xe-F bonds are polar covalent. XeF_4 has a square planar shape, due to the repulsions between four bonding regions and two non-bonding regions of charge; therefore the polarities/dipoles do cancel. As a result, XeF_4 is a non-polar molecule.

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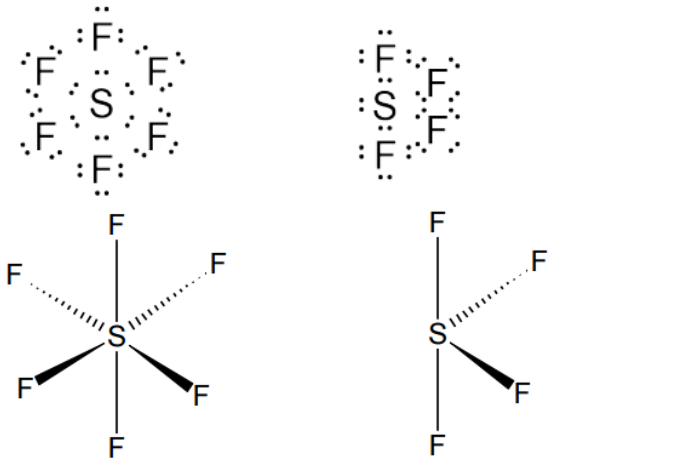
2012: 2 (From expired AS 90780)

(a)



Octahedral

See-saw or saw-horse or distorted tetrahedron

(b) ClF_3

Shape

- there are 5 regions of electron density around the Cl central atom • these repel to take a trigonal bipyramidal arrangement/ minimise repulsion / to get as far apart as possible
- there are only 3 bonding electron pairs/ 2 lone pairs • thus forming a T-shape arrangement.

Polarity

- the Cl-F bond is polar because of electronegativity difference • the molecule is NOT symmetrical • bond dipoles do not cancel OR charge is not symmetrically distributed over the molecule • so the molecule is polar.

AsF_5

Shape

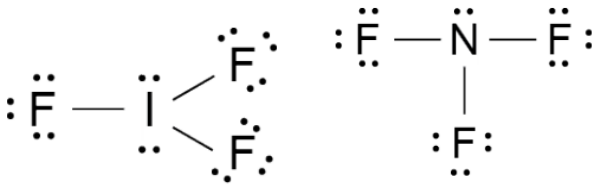
- has 5 electron pairs around the As central atom • these repel to take a trigonal bipyramidal shape /minimise repulsion / to get as far apart as possible • there are 5 bonding electron pairs/ all electron pairs are bonding • thus forming a trigonal bipyramidal arrangement.

Polarity

- As-F bond is polar because of electronegativity difference • molecule is symmetrical • bond dipoles do cancel • so the molecule is non-polar.

2011: 2 (From expired AS 90780)

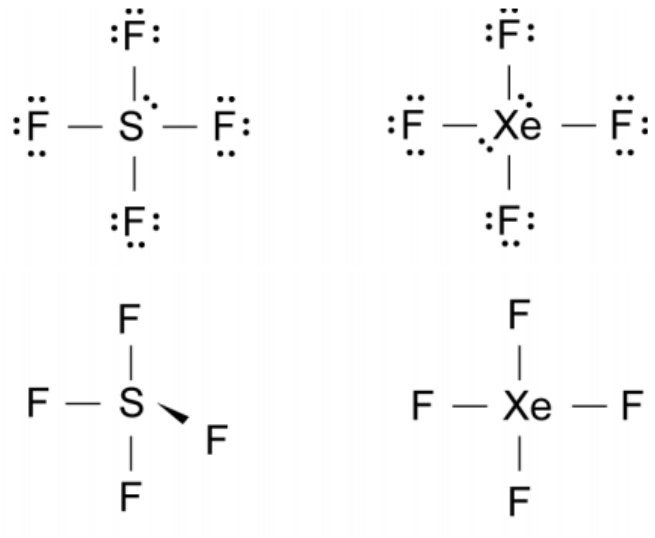
(a) IF_3 = T-shape NF_3 = Trigonal pyramid



(b) IF_5 • polar IF bond due to difference in electronegativity between I and F • molecule asymmetrical • bond dipoles do not cancel/centre of +ve and –ve charges correspond • molecule is polar.
PCl_5 • polar PCl bond due difference in electronegativity between P and Cl • molecule symmetrical • bond dipoles cancel / centre of +ve and –ve charges correspond • molecule is non-polar.

2010: 2 (From expired AS 90780)

(a) SF_4 XeF_4



seesaw / distorted tetrahedron square planar

(b) XeF_4
Shape • there are 6 electron pairs around the Xe central atom, • these repel to take an octahedral arrangement / minimise repulsion / to get as far apart as possible, • there are only 4 bonding electron pairs / 2 lone pairs, • forming square planar arrangement.
Polarity • the Xe-F bond is polar because of electronegativity difference, • the molecule is symmetrical, • polar bonds (NOT just bonds) cancel / centre of positive and negative charge correspond, • so the molecule is non-polar.
SF_4 Shape • has 5 electron pairs around the S central atom, • these repel to take a trigonal bipyramid shape / minimise repulsion / to get as far apart as possible, • There are only 4 bonding electron pairs / 1 lone pair, • forming see-saw arrangement.
Polarity • S-F bond is polar because of electronegativity difference, • molecule is not symmetrical, • polar bonds (NOT just bonds) do not cancel / centre of +ve and –ve charge do not correspond / polarities reinforce, • molecule is polar.